

# Ch 12 Mol Comp of Gases

Ch 11 in New

Volumes taken by gases  $\rightarrow$  reveals info about other props of gases

Dalton

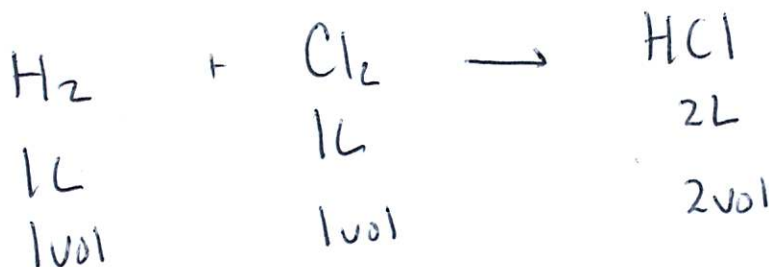
Measuring + Comparing Vol of Reactive Gases

Gay-Lussac

Saw



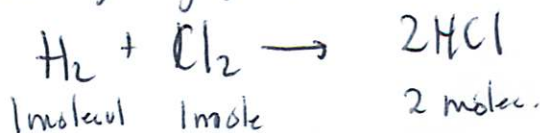
Also Saw



Gay-Lussac's Law of Combining vol - @ const T + P the V of gas reactants can be expressed as ratios of small whole #'s

Avogadro's hypothesis said  $\rightarrow$  equal Vol of gas @ same P + T have = # of molecules

$\hookrightarrow$  rejected Dalton by saying elements are diatomic makes sense



HIMWkon  
Pg 3

Went  
against  
Dalton  
but  
didn't  
know  
 $H_2$   
(atoms are  
indivisible)

Atoms not  
destroyed

1 mol of a gas has  $6 \times 10^{23}$  atoms or molecules

According to Avogadro's Principle - = Vol have same ~~the~~ molecules

Therefore 1 mol of any gas has same volume.

↳ This volume @ STP = 22.4 L

easier to measure mol of gas by Vol than mass

So  $\frac{1 \text{ mol}}{22.4 \text{ L}}$  is a conversion factor convert to mol ~~know~~ figure mass out.

Example → p 346, 347

Gas Density → Varies w/ T + P why B/c V changes

↳ Temp must be stated.

$$D_{\text{STP}} = \frac{\text{molar mass}}{\text{molar volume}} = \frac{\text{g/mol}}{22.4 \text{ L/mol}} = \frac{\text{g}}{\text{mol}} \times \frac{\text{mol}}{22.4 \text{ L}} = \frac{\text{g}}{22.4 \text{ L}}$$

Q 348

# Molar Mass @ STP from V

$$D_{STP} = \frac{\text{molar mass}}{\text{molar Vol}} \rightarrow \text{molar mass} = D_{STP} \times \text{mol Vol}$$

$$\frac{g}{L} \times \frac{22.4 L}{\text{mol}}$$

Do prob 348-349

IDEAL GAS Eqn  $PV = nRT \rightarrow$

Boyle's Law  $V \propto \frac{1}{P}$   
 Charles'  $V \propto T$   
 Gay-Lussac  $P \propto T$

Avogadro  $V \propto n$   
 $V \propto \frac{1}{P} \times T \times n$   
 Related by a const  
 $P \propto \frac{1}{V} \times T \times n$

$$PV = nRT$$

$$R = 0.082 \frac{L \cdot atm}{mol \cdot K}$$

To use this  
 Eqn  $V$  in L  
 $P$  in atm  
 $T$  in K

all prop ↑

$$\frac{PV}{RT} = R \text{ const!}$$

Ch 12 Q's p 350 q 6, 7

p 355 q 1, 3

p 360 q 1, 3, 4 H p 364 Q3

p 366 Q 1, 5, 7

p 367 Q 10, 11, 17, 20,

p 368 Q 31, App Prob

p 369 App Prob Q 22

Prob  
 Hand Q 10, 11, 12 p 367  
 18, 19 22

p 369 35, 37

Q 40, 364

Using Ideal gas Law

$PV = nRT \rightarrow$  can solve for any variable  $PVnT$

$\hookrightarrow$  make sure  $V = L, T = K, P = atm$  b/c  $R = 0.082 \frac{L \cdot atm}{mol \cdot K}$

Examples pg 352-353

Finding molar mass by ideal gas Law

$$mol = \frac{\cancel{\text{molar mass}} \cdot m}{\text{molar mass} \cdot M}$$

$$n = \frac{m}{M}$$

Substitute

$$PV = \frac{mRT}{M}$$

$$M = \frac{mRT}{PV}$$

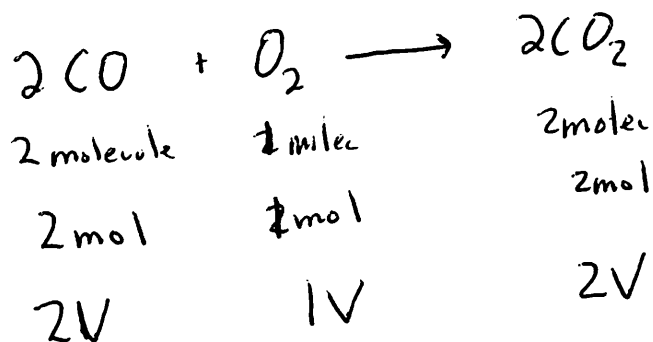
$$\text{Density} = \frac{m}{V}$$

$$\rightarrow M = \frac{DRT}{P} \quad D = \frac{MP}{RT}$$

Examples p 355

# Stoichiometry of Gases

Thanks to Gay-Lussac + Avogadro



Ratio examples

$$\frac{2 \text{ vol CO}}{1 \text{ vol O}_2} \text{ etc}$$

Vol-Vol Stoic

If 4 L of CO are used how much O<sub>2</sub> needed?

$$4 \text{ L CO} \times \frac{1 \text{ vol O}_2}{2 \text{ vol CO}_2} = 2 \text{ L O}_2$$

Not cut and dry mass  $\rightarrow$  Vol

Vol  $\rightarrow$  mass

process  $\rightarrow$  gas Vol A  $\rightarrow$  mol A  $\rightarrow$  mol B  $\rightarrow$  mass B

mass A  $\rightarrow$  mol A  $\rightarrow$  mol B  $\rightarrow$  Vol B

$$\text{@STP} \quad \frac{22.4 \text{ L}}{1 \text{ mol}}$$

or use Ideal @ Non Standard  
 $PV = nRT$

Sample problem 359

## 12.4 Diffusion + Effusion

Constant motion of gas molecules causes them to spread out.

Diffusion - mixing of 2 gases due to their spontaneous  
Random motion

Show overhead

Effusion - Container w/ a small opening gases will encounter  
it and pass through.

But the rate of both depends on --  $T, M$

Vel varies inversely w/ mass  $M \uparrow, V \downarrow$

For Temp (measure of Avg KE) @ a given  $T$

$$KE = \frac{1}{2}mv^2 \leftarrow \text{Physics (we are talking about particles in motion)}$$

Diffusion is ~~the~~ better understood by looking @ 2 gases  
Effusion @ same  $T + P$ .



where gas =  $\left\{ \begin{array}{l} KE_A = \frac{1}{2} M_A v_A^2 \\ KE_B = \frac{1}{2} M_B v_B^2 \end{array} \right.$  Temp!

M = molar mass

So  $\frac{1}{2} M_A v_A^2 = \frac{1}{2} M_B v_B^2$

$\boxed{M_A v_A^2 = M_B v_B^2}$  Better to compare them as velocities as a ratio

So  $\frac{v_A^2}{v_B^2} = \frac{M_B}{M_A} \xrightarrow{\text{reduce}} \frac{v_A}{v_B} = \frac{\sqrt{M_B}}{\sqrt{M_A}} = \frac{\text{rate of effusion A}}{\text{rate of effusion B}}$

Scottish Chemist Thomas Graham

Graham's Law of effusion/diff { molecular velocities of gases are inversely proportional to the square roots of their molar masses at the same T

Can vary it too!

$\frac{\text{rate of effusion A}}{\text{rate of effusion B}} = \frac{\sqrt{M_B}}{\sqrt{M_A}} = \frac{\sqrt{D_B}}{\sqrt{D_A}}$

or  $\frac{\text{effusion time A}}{\text{effusion time B}} = \frac{\sqrt{M_B}}{\sqrt{M_A}} = \frac{\text{dist traveled A}}{\text{dist traveled B}} = \frac{\text{molecular vel A}}{\text{molec vel B}}$

Do Demo of  $\text{NH}_3 + \text{HCl}$  in tube

Applications  $\rightarrow$  in Technology can use to separate light isotopes  
from heavy isotopes

also Calculation of unknown molar mass.

Compare rate effusion of known to unknown + calc  
Molar mass!

Sample Prob 12.14

$$M_A = \text{H}_2 = 2.0 \text{ g/mol}$$

$$M_B = \text{O}_2 = 32.0 \text{ g/mol}$$

$$\frac{\text{rate A}}{\text{rate B}} = \frac{\sqrt{32.0 \text{ g/mol}}}{\sqrt{2.0 \text{ g/mol}}} = \frac{5.6}{1.4} = \frac{4}{1}$$

$\text{H}_2$  diffuse 4X as fast!

Practice Prob

$$\frac{\text{rate A H}_2}{\text{rate B X}} = \frac{8.94}{1} = \frac{\sqrt{X \text{ g/mol}}}{\sqrt{2.0 \text{ g/mol}}} = 79.9 = \frac{X \text{ g/mol}}{2.0 \text{ g/mol}} = 160. \text{ g/mol}$$